TITLE OF THE INVENTION

PULSATOR CONTROLLER FOR MONITORING AND CONTROLLING A DESIGNATED PULSATOR IN A MILKING SYSTEM AND METHOD OF USING SAME

CROSS-REFERENCES TO RELATED APPLICATIONS

This Application claims the benefit, under Title 35, United States Code §119(e), of United States Provisional Patent Application Serial No.: 60/445,876 filed February 7, 2003.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCE TO A "MICROFICHE APPENDIX" (SEE 37 CFR 1.96)

Not Applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to apparatus, method and system of supervising, monitoring and controlling all of the pulsators of a milking machine having a teatcup with a teatcup liner and a pulsation chamber comprising applying a milking vacuum to the interior of the teatcup liner and a pulsating vacuum to the pulsation chamber so that the teatcup liner cyclically moves between a substantially open position and a substantially closed position under control of pulsation vacuum

pulses from a pulsator and more particularity relates to a pulsator controller for a milking machine comprising a teatcup with a teatcup liner and a pulsation chamber, a vacuum source for generating a milking vacuum in the interior of the teatcup liner and a pulsator provided to alternately connect the pulsation chamber to the atmosphere and to the vacuum source for generating a pulsating vacuum in the pulsation chamber to produce a pulsating movement of the teat cup liner between a substantially open position and a substantially closed position wherein the controller signals that a designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range based on a stored reference signal received by a processor in a controller representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators.

2. Description of the Prior Art

Milking systems having a vacuum for performing milking of dairy animals, such as cows, are well known in the art. Certain of the milking systems have the milking process for dairy animals, such as cows, automated to facilitate faster and consistent milking of dairy animals.

A reference entitled MACHINE MILKING AND LACTATION by A. J. Bramley, F. H. Dood, G. A. Mein and J. A. Bramley, published by Insight books, Vermon, USA, describes the history, background and state of the art in milking systems and in Chapter 7 entitled

Basic Mechanics and Testing of Milking Systems by G. A. Mein appearing at Pages 235 through 284, discloses and describes typical milking machine installations (the "Bramley et al. Reference"). United States Patent 5,896,827 discloses a milking system having a substantially stable continuous vacuum level through a milk claw and milk hose wherein the milking system includes a milking apparatus for connection with an animal's teats to apply a controlled vacuum thereto to remove milk therefrom at various milk flow rates.

As milking systems become automated, milking system include monitoring apparatus for monitoring other functions in the milking system and for generating a signal if certain unacceptable operating condition occur. Examples of such monitoring apparatus are disclosed in the following United States Patents.

United States Patent 4,616,215 discloses a vacuum monitoring apparatus which includes a control circuit having a transducer for sensing the vacuum levels in a milking system and for generating output signals. The control circuit includes a comparator for controlling indicator devices and an alarm circuit in response to a set point when the vacuum levels are at high, low and normal settings. The control circuit includes a time delay circuit that disables the alarm circuit for a predetermined time delay to provide for measurement of the vacuum recovery rate for the system.

United States Patent 4,605,040 discloses a partial-vacuum regulating valve that automatically regulates an operating partial vacuum in milking systems. The partial-vacuum regulating valve consists of a main valve and an auxiliary valve. The auxiliary valve body is adjusted in accordance with the partial vacuum prevailing in the milking system and affects the amount of air that is drawn out of the main valve control chamber, which communicates with the atmosphere through a calibrated bore, through a certain channel. The partial-vacuum is adjusted in the control chamber in accordance with the amount of air drawn out and that adjustment determines the position of the auxiliary valve. The position of the auxiliary valve determines the amount of air flowing into a certain line through the air-inlet opening, which in, turn, affects the partial pressure in the line. The main-line control chamber has an additional calibrated air inlet that is closed off with a cap. When the cap is removed, atmospheric air also flows through the additional inlet into the main valve control chamber and reduces the partial vacuum therein. The associated descent of the valve body reduces the air admitted onto the line and hence leads to partial pressure in the milking system that is lower than the partial pressure established for the milking process by means of a screw and spring.

United States Patent 4,572,104 discloses a method of milking for a double action milking system. Milking is initiated at one

ratio of milk period and then increased to a selected higher ratio. Milking is then done at the selected higher ratio for a selected segment of time or until the milk flow rate falls below a predetermined value, after which the ratio is decreased so that milking is completed at a lower ratio. A valve is used to selectively alternatively connect a line going to the teat cups to vacuum or to atmospheric pressure.

United States Patent 4,516,530 discloses an automated milking system in which the milking vacuum applied from a vacuum line through a milk flow valve and the milk hose to a teat cup cluster is initially shut off after automatic detacher controls provide a signal indicating the end of milking. A milk sweep controls a backflush system which passes a flushing fluid through the milk flow valve into the milk house and teat cup cluster to flush out these components.

United States Patent 3,783,837 discloses a milking machine having a duct under partial vacuum that leads milk from the teat cup cluster to form a milk flow having a milking flow rate. The duct has a regulating valve which is used to vary the milking vacuum. A device for sensing changes in the rate of milk flow through the duct is connected to control means for operating the regulating valve to an idling value in response to a decrease in the milk flow rate and an increase in the milking vacuum from an idling value to a working value in response to an increase in the rate of milk flow.

One example of automated dairy barn or milking parlor is a herringbone milking stall parlor wherein the dairy animal is directed into a milking stall. Once the dairy animal is in the stall a milking apparatus, comprising a milking claw and inflations, have the inflations thereof attached to the teats of a dairy animal to perform the milking process which commence when the milking vacuum is enabled or turned on. The inflations are each formed of a separate teat cup and teat cup liner assembly that are attached to the teats of the dairy animal. Typically the inflations have four teat cup and teat cup liner assemblies, one for each teat of a dairy animal, e.g. a cow.

Each teat cup has a shell and a teat cup liner is provided in the shell to form a pulsation chamber between the teat cup liner and the shell. During milking, the interior of the teat cup liner is subjected to a varying milking vacuum that typically varies over a range of about 10 inches Hg to about 12 inches Hg and then to atmospheric pressure. The pulsation chamber is subjected to a cyclically pulsating vacuum normally varying between atmospheric pressure, when the teat cup liner is collapsed or closed, and a maximum vacuum level of about 12 inches Hg when the teat cup liner is fully open. The maximum pulsating vacuum level is normally about 12 inches Hg under atmospheric pressure, i.e. equal to the milking vacuum level. This means that the pressure difference across the wall of the

teat cup liner is essentially equal to zero when the teat cup liner is closed.

In the state-of-the-art milking systems, the pulsating vacuum is controlled by a pulsator as described above. The pulsator has a pulsation cycle which is divided into four phases; (i) an opening phase (a) during which the pulsating vacuum increases from atmospheric pressure to the milking vacuum level and the teat cup liner moves from a closed position to an open position, (ii) an open phase (b) during which the pulsating vacuum has reached its maximum level, which is substantially equal to the milking vacuum level, the teat cup liner is in an open position allowing milk to flow from a teat, (iii) a closing phase (a) during which the pulsating vacuum decreases from about the milking vacuum level to the atmospheric pressure and the teat cup liner moves from the open position to the closed position, and (iv) a closed phase (d) during which the pulsating vacuum is equal to the atmospheric pressure and the teat cup liner is in a closed position stopping milk flow from a teat. The above action of the pulsator is referred to herein generally as the "pulsation process". Each of the above phases are referred to as Phase A, Phase B, Phase C and Phase D, respectively. Typically, a pulsator is programmed for about 60 cycles each of Phases A, B, C and D per minute.

Each milking apparatus has a separate pulsator for controlling each teat cup shell and a teat cup liner by applying

a vacuum to each pulsation chamber between the teat cup liner and the shell. The pulsator and the pulsation system is a vital part of a milking facility. There is usually one pulsator designated for each milking apparatus being used to milk a dairy animal, e.g. a cow. If a milking parlor or milking barn has "N" milking apparatus all capable of milking cows at the same time, the milking parlor or milking barn would typically have "N" separate pulsators.

As discussed above, monitoring of the pulsation process, during which the teat cup liner movement occurs, is very important to the health and milk production of a cow. Improper or defective operation of a pulsator or a malfunction of a pulsator, if allowed to go unnoticed for a considerable period of time, can cause damage to the cow. Such damage results because of trauma experienced by the teat of a dairy animal arising from improper teat cup liner movement and such damage could include causing mastitis to the dairy animal.

Mastitis is an infection of animal body tissue within the mammary system of an animal. Mastitis may be caused by a number of other conditions including irritation to the teats, as is well known to persons skilled in the art. When mastitis occurs, it is an infection that the animal, e.g. cow's, body must counteract. Thus the animal's body energy is to be used to fight infection rather than produce milk.

If the infection is severe enough, significant and sometimes permanent damage can be caused to the cow's normal milk producing organisms. All mastitis cause some level of permanent and lifetime irrefutable damage to the animal's milk producing (mammary) system. The level of severity is in direct relation to the severity and length of time that an infection exists. As such, a severe or lengthy period of infection may limit the animal's production capabilities and affect the animal's milk producing life.

A milking machine, milking apparatus or milking system generally causes mastitis in two ways.

First, mastitis is caused by application of damaging vacuum levels to the cows' teats which create a severe irritation. Since it is difficult to isolate with any degree of certainty at what level of vacuum such irritation occurs, the conservative approach is the least level of vacuum, the better. Each animal, such as a cow, reacts differently to vacuums being applied to teats and each animal tolerates various levels of vacuum differently.

Second, mastitis is created by a milking apparatus, causing foreign bacteria to be introduced into the animal, e.g. cow. As milk is being drawn from the cow, the teats are exposed to a vacuum which is less than atmospheric pressure. However, the outside of the udder is under atmospheric pressure and, in essence, atmospheric pressure is what is "squeezing" the milk out

of the animal's teats in response to a periodic pulsating or controlled vacuum from a pulsator.

If a pulsator is defective, is not operating properly or if a malfunction occurs affecting the pulsation process, it is desirable to detect and correct such a condition as soon as possible. Doing so will most likely limit or prevent damage or injury to a dairy animal and help maintain the dairy animal in a healthy condition for giving milk. A dairy animal in good health produces a higher volume of milk during each milking cycle.

One known method for insuring proper operation of the pulsators and pulsation process is to test the milking system on a monthly basis using a recorder for measuring vacuum levels of each of the pulsators and the measuring the pulsation phases of the pulsation cycles. Based on the test results, appropriate repairs can be made to the pulsator, vacuum lines and milking apparatus as required to remedy the identified deficiency or malfunction.

Between tests, an improperly operating pulsator or other malfunction or deficiency in the milking system related to the pulsating process can go unnoticed for an extended period of time, sometimes as long a month, when the next test is scheduled to be conducted.

In the prior art monthly pulsator monitoring testing program, each pulsator is tested on an individual basis and a determination is then made whether the pulsator operates within

an acceptable standard. If the pulsator's operation is deficient or if the pulsator malfunctions, the pulsator is repaired or replaced, as necessary.

Other known apparatus for monitoring and controlling pulsators disclosed in certain United States Patents are discussed below.

United States Patents 6,009,832 and 6,073,579 disclose a milking machine having a teat cup with a teat cup liner and a pulsation chamber. The abrupt movement of the teat cup liner when the teat cup liner moves to an open or closed position is sensed. If a sensed movement does not fulfill a predetermined condition, a signaling means signals the malfunction.

United States Patent 5,443,035 discloses a milking machine pulsation control that includes a micro controller which generates a pulse width modulated drive signal to control current to pulsator valves, with a high current for pull-in and a lower current for holding. A watchdog circuit resets the computer in the event of latch-up as a result of circuit transients.

United States Patent Application Publication No: 2002/0104484 published on August 8, 2002 discloses a method and apparatus for monitoring the operation of a pulsator by recording calibration data from that specific pulsator during a calibration mode made on that specific pulsator during normal operations and using the so recorded pulsator specific calibration data for comparison using a processor with data developed from that

specific pulsator during milking operation and the processor provides a signal to an output, which signal indicates if the pulsator is operating.

None of the known prior art anticipates, discloses, suggests or teaches or a controller for monitoring and controlling pulsators in a milking system wherein the referenced data stored in a computer system is a programmed standard for an acceptable predetermined vacuum range of pulsating vacuum levels for a pulsator is predetermined for the milking system. The programmed standard for an acceptable predetermined vacuum range for a pulsator predetermined for the milking system is entered into and stored in the computer system as a reference standard for monitoring operation of all of the "N" pulsators in the milking system. The controller includes sensors and verifies that a milking apparatus is attached to a dairy animal during a milking operation.

In the method and apparatus for monitoring the operation of a pulsator disclosed in United States Patent Application Publication No: 2002/0104484 published on August 8, 2002, each separate pulsator must be calibrated individually, recorded separately in a separate recording step and that calibration data can only be used with that specific pulsator during monitoring. If milking parlor or milking barn has "N" milking systems, then "N" pulsators must be separately calibrated, that calibration data must be stored as recorded data for each pulsator, and each

compare cycle is required to address each specific calibration data for each specific pulsator.

In addition, the method and apparatus for monitoring the operation of a pulsator disclosed in United States Patent Application Publication No: 2002/0104484 published on August 8, 2002 does not anticipate, disclose, suggest or teach verifying that the milking apparatus is attached to a dairy animal during monitoring of the specific pulsator of a specific milking apparatus to avoid generation of error signals.

BRIEF SUMMARY OF THE INVENTION

The present invention discloses and teaches a new, novel and unique controller for monitoring and controlling operating pulsators in a milking system. The controller for monitoring and controlling operating pulsators in a milking system includes a first input configured to be operatively connected to a designated pulsator for receiving the pulsating vacuum. A first sensor receives the pulsating vacuum and produces a first signal representing the pulsating vacuum level received from the designated pulsator selected from an "N" number of pulsators operating in a milking system. The controller further includes a processor operatively connected to the first sensor for receiving the first signal representing a pulsating vacuum level from the designated pulsator being monitored. The processor includes a comparator for comparing the first signal representing a pulsating vacuum level from the designated pulsator being

monitored to a stored reference signal applied to the processor from a computer and the stored reference signal represents a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for all milking system pulsators. The processor generates at least one control signal when the designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range. A control circuit is responsive to the at least one control signal for signaling that the designed pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

Therefore, it is an advantage of the present invention to provide apparatus, a system and method for monitoring and controlling operating pulsators in a milking system.

Another advantage of the present invention is that a microprocessor in the pulsator controller generates at least one control signal when the monitored pulsator pulsating vacuum level is at a vacuum level outside of a programmed predetermined vacuum range.

Another advantage of the present invention is that the pulsator controller has a control circuit for signaling that a monitored pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

Another advantage of the present invention is that the pulsator controller control circuit is capable of disabling operation of the monitored pulsator having a pulsating vacuum level which is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

Another advantage of the present invention is that the is that the pulsator controller can generate at least one of an acceptable control signal when the designated pulsator pulsating vacuum level is at a vacuum level within the predetermined vacuum range programmed as acceptable for the milking system pulsators and an unacceptable control signal when the designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range.

Another advantage of the present invention is that the pulsator controller control circuit is responsive to an unacceptable control signal and to an acceptable control signal to enable a red illumination device and a green illumination device, respectively.

Another advantage of the present invention is that the pulsator controller can be used in a system for monitoring and controlling an operating pulsator in a milking system.

Another advantage of the present invention is that the pulsator controller can be used in a method for monitoring and controlling an operating pulsator in a milking system.

Another advantage of the present invention is that the pulsator controller verifies that the milking apparatus is attached to a dairy animal during monitoring and that the milking vacuum is on to avoid generation of error signals.

Another advantage of the present invention is one of the known causes of mastitis can be significantly reduced by using the pulsator controller of the present invention which leads to greater milk production and improved health of a dairy animal or cow.

Another advantage of the present invention is that the pulsator controller can be used to control or adjust the operating parameters of the pulsator. This would include adjusting the on time to off time ratio and adjust the duration of one or more of the Phases A, B, C and D.

Another advantage of the present invention is that the pulsator controller can be used to produce an information signal which can be used to identify the cause of a pulsator malfunction by generating a visual display representing the matched pulsator malfunction criteria for the designated pulsator. The visual display may be in the form of a light, a written message on an annunciator or a written message on a video monitor.

Another advantage of the present invention is that the pulsator controller processor includes a memory for storing pulsator malfunction criteria as a reference table and stored reference signals representing a predetermined vacuum range of

pulsating vacuum levels programmed as acceptable for milking system pulsators wherein the data stored in the memory is from a programmable device. In the preferred embodiment, the programmable device is a remote computer having a memory operatively coupled to the processor.

BRIEF DESCRIPTION OF THE DRAWING

Thc present invention will become more fully understood from the following detailed description of a preferred but non-limiting embodiment thereof, described in connection with the accompanying drawings, wherein:

Fig. 1 is a pictorial representation of a milking system illustrating the milking apparatus, milk claw, milk hose, control device, milk line and associated components of the milking system;

Fig. 2 is a pictorial representation of a milking apparatus comprising a milk claw and four inflations wherein each inflation has a teat cup having a shell and a teat cup liner provided in the shell to form a pulsation chamber between the teat cup liner and the shell and a pulsator for providing pulsation vacuum level pulses to each inflation and a controller using the teachings of the present invention for monitoring and controlling the pulsator;

Fig. 3 is a chart plotting the milk flow rate as a function of time during a typical milking cycle of a cow;

Fig. 4 is a chart plotting vacuum level of the vacuum source as a function of time during normal startup, operation of and shut-down of the vacuum system illustrated as part of Fig. 1;

Fig. 5 is a pressure/time graph showing by means of a continuous line how the pulsating pressure in a pulsation chamber of a teat cup having a teat cup liner varies during a pulsation cycle;

Fig. 6 is a schematic representation of a pulsator controller illustrated as being operatively connected to a pulsator of a milking apparatus;

Fig. 7 is a schematic diagram of the overall data processing system for controlling and monitoring all pulsators in a milking system;

Fig. 8 is a detailed block diagram of a controller for practicing this invention;

Fig. 9 is a flow chart showing the steps of method of using the pulsator controller for monitoring and controlling a pulsator;

Fig. 10 is message sub-routine flow chart showing the steps of method of using the pulsator controller for monitoring and controlling a pulsator;

Fig. 11 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing an alarm configuration for a designated pulsator;

Fig. 12 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing programmed stored reference signals to be applied to the processor from the computer system wherein the stored reference signal represents a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators;

Fig. 13 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing programmed phases of the pulsation cycle in milliseconds to be applied to all of the milking system pulsators; and

Fig. 14 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing programmed phases of the pulsation cycle in percentage of a full pulsation cycle to be applied to all of the milking system pulsators

Fig. 15 is a modification of the detailed block diagram of a controller of Fig. 8 which includes a memory for storing pulsation malfunction criteria in a look up table, an output for adjusting pulsator operating parameters and a pulsator malfunction display;

Fig. 16 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing programmed phases of the pulsation cycle in

milliseconds to be applied to all of the milking system pulsators and that none of the designated pulsators are malfunctioning;

Fig. 17 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing programmed phases of the pulsation cycle in milliseconds to be applied to all of the milking system pulsators and wherein the pulsator controller programs; (a) cycles to average for reading; (b) programmed alarm levels for: (i) percentage tolerance variation of programmed vacuum pulse levels to trigger alarm; (ii) Phase D maximum vacuum; (iii) Phase B maximum and minimum vacuum level and (iv) minimum phases timed durations for Phases A, B, C and D; and

Fig. 18 is a flow chart showing pictorially the order in which the programmed alarmed levels are monitored to provide an information signal designating a pulsator malfunction criteria.

DETAILED DESCRIPTION OF THE INVENTION

Before proceeding with the description of the preferred embodiment, the following background will be helpful in understanding this invention.

Description of Milking System

When a cow enters a milking barn or milking parlor, such as a herring bone style milking parlor, and the milking machine or milking apparatus is connected to the animal's body and a milking vacuum is applied to the apparatus, the body starts to react in preparation for "letting down" of the diary animal's, e.g. cow's,

milk. A natural process takes place wherein the animal produces within the animal's blood stream a chemical called "oxitosin". This chemical works its way down into the udder causing the ovili cells to contract. In essence, contraction of the ovili cells causes a squeezing effect to help push out, expel or withdraw the animal's milk. The period of time the animal produces this oxitosin is limited, and recent research suggests somewhere between 4 minutes and 6 minutes on average.

Once an animal stops producing oxitosin, it becomes difficult, if not impossible, to withdraw or remove any remaining milk from the animal. When milk is left in the udder of the animal, nature "tells" the animal's body that it does not need to produce as much milk. Therefore, when this happens the animal's body will level off milk production and eventually decreases production during that lactation.

When a cow begins lactation, the cow increases its production of milk each day as a natural response to "feed" the animal's growing baby calf. At some time during that lactation, the cow will naturally level off and then begin a decrease in production. This is nature's way of "weaning" off the calf.

In the state-of-the art milking systems, monitoring of the pulsation process, during which the teat cup liner movement occurs, and monitoring of all of the pulsators, which control the teat cup liner movement, have become very important because an

undetected defective or malfuncting pulsator, can affect the health and milk production of a cow.

With this in mind, one can conclude it is important to that all pulsators are operating properly, otherwise the dairy animal could suffer damages to its teats which likely could result in the dairy animal producing less milk. For these reason, properly operating pulsators are important to the dairyman and the teachings of this invention will directly maintain the health of dairy animals and will enhance withdrawing of milk during the period of time the animal is "naturally" willing to give milk.

The pulsator controller for a milking system using the teachings of this invention represents an important advancement in the state-of-the-art dairies.

The pictorial drawing of Fig. 1 illustrates a milking system showing generally as 20 which is installed in a milk parlor operation having a plurality of vacuum-operated milking machines shown generally as 22 in individual stalls.

In Fig. 1, a source of vacuum is provided to the milking system by vacuum pump 24 through a vacuum conduit 26 to a vacuum manifold header 30. A vacuum regulator 32 is operatively connected to the vacuum conduit 26 to control the maximum vacuum that would be applied to the milking system. Typically, the vacuum level in a milking system is in the order of 12 inches of Hg (12" Hg).

The vacuum manifold header 30 is operatively coupled by a pulsation line 36 to a pulsator 40.

The pulsation line 36 is generally a plastic or steel line that carries vacuum, equal to the desired preset vacuum level, to the pulsator 40. Pulsation line 36 must be adequately sized to carry air away from the pulsator without allowing a drop in vacuum (lower than the milking vacuum level).

The pulsator 40 is a device that intermittently applies pulsating vacuum pulse through flexible conduit 50 from within the shell (outside the liner) of the inflation 42 and creates a vacuum to "pull" to "open" the inflation 42 away from or releasing the teat of the cow making the teat open so that the vacuum from the milk claw draws milk down thorough the teat. This is referred to as a "milk period". Alternatively, atmospheric pressure is applied by the pulsation 40 to the liner to "push" or "close" the inflation 42 against the teat of the cow closing off the teat. This is referred to as a "rest period". The pulsator 40 periodically draws air out of the inflation 42 by application of pulsating vacuum pulses at a controlled vacuum level to create the cycle of opening and closing of the teat cup liner. This creates a situation of milking (teat under vacuum) and rest (teat not under vacuum).

As illustrated in Fig. 1, the vacuum pump 24 removes air from the milking system to create less than atmospheric pressure within the milking system. The vacuum manifold header 30 is

essentially a distribution manifold that allows both the milk line 76 and pulsation line 36 to have equal access to the vacuum source, which in this embodiment is a vacuum pump 24 and vacuum regulator 32.

The vacuum regulator 32 is a vacuum level controller which is a device that maintains a predetermined or preset vacuum level within the milking system 20. A typical vacuum pump 24 has capacity to draw vacuum levels lower than the levels desired in the basic milking system 20. The vacuum regulator 32 includes an air inlet to vary or balance the capacity of the vacuum pump 24 or to change the air introduced into the milking process during normal operation. At times when the milking system 20 is intermitting air equal to the vacuum pump 24, the vacuum controller or vacuum regulator 32 will be off (no air inlet). When the milking system is intermitting air less than the capacity of the vacuum pump 24 capacity, the vacuum regulator 32 will open and "make-up" the difference to maintain a constant and predetermined level of vacuum into the milking system 20 equal to the capacity of the vacuum pump 24.

Referring back to Fig. 1, the milking apparatus shown generally as 22 has the inflations 42 which define the teat-engaging portion of a teat cup cluster. The milking apparatus 22 is adapted to have the inflations 42 operatively connected or operatively attached with an animal's udder, such as for example a cow's udder 44, having teats 46 to apply a controlled vacuum to

the teats 46 to remove milk therefrom. The inflations 42 include a shell and liner 48 which have an "open" and "closed" position depending upon the vacuum pressure applied thereto as described hereinbefore. The vacuum pulsator 40 is operatively connected by a flexible vacuum lines 50 to control the shells and liners 48.

The shells and liners 48, comprises two components. The first component is a liner which is a soft rubber tube that goes around the cow's teat 46 to seal it off from atmospheric pressure to allow the vacuum to draw milk from the cow's udder 44. The other component is a shell which is a rigid device that houses the liner and can seal the outside of the liner from atmospheric pressure. The shells and liners 48 cooperate to selectively or controllably apply vacuum to the cow's udder 44 and teats 46 to withdraw the milk.

A milk claw 60, is operatively connected to the inflations 42 by means of flexible tubing 62, to receive milk from the inflations 42 at various milk flow rates. The milk claw 60 receives and passes the milk under a stabilized continuous vacuum in a vacuum channel at a selected vacuum level and, most importantly, at peak milk flow rates. The milk claw 60 includes an outlet 64 having side walls and a predetermined cross-sectional area, which in the preferred embodiment, is selected to be in the range of: (i) a minimum cross-sectional area for maintaining at all milk flow rates a substantially uniform laminar flow of milk there through and for concurrently providing

a stabilized continuous vacuum in a vacuum channel between the laminar flow of milk and the interior walls of the outlet 64; and (ii) a maximum cross-sectional area equal to about 1.5 times the minimum cross-sectional area of the outlet 64. Certain of the known prior art systems have a milk claw having an outlet having a diameter of 5/8 inch. The teachings of this invention can be used in all of the known prior art milking system having using any of the known milk claws.

In the preferred embodiment, the milk claw 60 has four (4) inflations 42 since a cow has (4) four teats. The inflations 42, under controlled vacuum pressure from the pulsator 40, extracts milk from the cow's udder 44 as described hereinbefore. The milk claw 60 functions as a manifold device (claw) that brings the milk from four inlets into single outlet.

The milk claw 60 further may optionally include a control orifice 70, which is in the form of a calibrated orifice, for controllably admitting atmospheric pressure to the milk claw 60. Control orifice to functions for controlling the vacuum level within the milk claw outlet 64. Also, the milk claw 60 has a housing 66 that has a central chamber 104 defined by sidewalls 106.

In the alternative, the inflations 42 may optionally include a control orifice shown as 70'. Also, both the milk claw 60 and the inflation 42 may each have a control orifice 70 and 70' respectively, as the case may be.

It is desirable to intermit air to the vacuum system at this point in the milk claw 60 as the cow produces fluid milk, it would otherwise be difficult to transport the milk away from the cow without approaching flooding. Therefore, the milk claw 60 may have an air bleed port or control orifice 70 formed therein.

The milk claw outlet 64 is operatively connected by a milk transport conduit, shown generally as 72. The milk transport conduit 72 includes a semi-flexible hose 78 operatively connected to a nipple inlet 80 of a milk line 76.

The term "milk transport conduit" is intended to cover any flexible conduit material such as a semi-flexible hose used in a milking system. Preferably, the milk transport conduit has a cross-sectional area substantially equal to the cross-sectional area of the outlet 64.

The term "milk transport conduit" is intended to also include any other intermediate in line components, devices, control apparatus or the like (such as, for example, a milk flow measuring device for terminating or shutting off the vacuum at the end of a milking cycle 82 shown in Fig. 1) vacuum sensing devices and the like.

In the embodiment illustrated in Fig. 1, the milk transport conduit is in the form of a semi-flexible clear plastic hose 78 which is operatively connected to an inlet nipple 80 of the milk line 76. In the preferred embodiment, the semi-flexible hose 78

is a plastic or rubber hose connecting the milking claw outlet 64 to the inlet nipple 80 as described above.

The milk line 76, commonly referred to as a milk transfer line, is in the form of a stainless steel line with adequate capacity to carry vacuum to the cow from the vacuum source 26. The vacuum manifold header 30 applies vacuum via a conduit 84 and a moisture trap 86 to a receiving vessel such as a receiving jar 90 which is in the form of an enclosed vessel functioning as a vacuum chamber. The receiving jar 90 is operatively connected to a milk pump 96 to remove the milk collected in the receiving jar 90.

The milk line 76, under a vacuum which is applied thereto through the receiving jar 90, transports the milk away from the cow to the receiving jar 90 where it is accumulated and pumped away by milk pump 96.

It is important for the milk transfer line 76 to have enough capacity to carry milk away from all individual milking apparatus 22 while still leaving adequate capacity to form a vacuum channel for unrestricted, stable, continuous closed vacuum system to the cow's udder 44.

The milk transfer line 76 and receiver jar 90 must be sized to have enough capacity such that the milk flow will not fill the line, e.g. flood the line, which would block the vacuum channel and flow of vacuum to the milking apparatus 22 operatively connected to the cow's udder 44.

In addition, the milking system can have control valves, such as 80 and 80' which are used to enable or to turn on the milking vacuum on or to disable the milking vacuum or to turn off the milking vacuum. The control valves 80 and 80' may include or cooperate with a sensor for detecting whether the milking vacuum is on or off and the sensor can generate a vacuum control signal verifying that the milking vacuum is present. The vacuum control signal can be used as a verification signal for the monitoring and control functions as discussed hereinafter.

Description of Operation

In operation, the milk line 76 is under a vacuum that is transported through a vacuum channel in the milk hose 78 and milk claw 60 through the inflations to the cow's udder 44. The pulsator 40 periodically applies vacuum to the inflation forming the "milk period" and "rest period". During the "milk period", the vacuum is what "draws" the milk from the cow. If a vacuum was constantly applied on the cow's udder, the udder could be damaged. Therefore, it is necessary to "turn off" that vacuum at regular intervals during the milking process. Typically, that is on/off (milk/rest) ratio which is about between about 50% on - about 50% off to about 70% on - about 30% off. These cycles are typically in the order of between about 40 to about 60 times per minute.

This on/off cycle occurs within the inflation such that when the vacuum passing through the vacuum channel of the milk

line 76 reaches the inflation 42, the inflation collapses under that vacuum and pinches off vacuum to the cow's udder 44. To open the inflation, the pulsator 40 applies an equal vacuum to the outside of the inflation 42 and pulls it open causing vacuum to flow to the cow's udder and retract the animal's milk. As the inflation 42 opens, vacuum will draw the milk from the cow's udder 44 where it is ultimately transported to the milk-receiving jar 90. To help move the milk thorough the system, one or more air bleed ports or control orifices are introduced in the system as discussed above including within the milking claw 60.

Fig. 1 illustrates diagrammatically the controller 104 for monitoring and controlling operating pulsators in a milking system. Controller 104 is typical of a controller which would be operatively connected to each one of all of the pulsators in the milking system. If the milking system as "N" milking apparatus, each milking apparatus would have a pulsator similar to pulsator 40. Thus, each milking system having "N" pulsators would also have "N" controllers, one for monitoring each of the pulsators. As discussed herein below in Fig. 7, each pulsator is operatively connected to and controlled through the controller by a system computer having a memory which has as stored data therein in the form of a stored reference signal representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for all of the milking system pulsators.The system computer can control and/or program operation of all pulsators by setting,

controlling a monitoring all parameters such as phase periods, pulsation factors and the like.

The controller 104 has a first input 102 having a first sensor 106 which is configured to be operatively connected to the pulsator 40 via vacuum test port lines 108 which are operatively connected to the pulsation line 50 of the pulsator 40. The pulsator 40 has controlling solenoids 54 which are operatively connected via power lead lines depicted by arrow 52 to the controller 104 to apply a 24 volt, direct current power from the controller 104 to the operation of solenoids 54. The controller 104 can control the application of power to and the removal of power from controller 40 via power lead lines 52.

The controller 104 includes a processor 110 having a control device 112 and a monitoring device 114. The processor 110 monitoring device 114 is operatively connected to the first input 102 for receiving from the sensors 106 a first signal representing a pulsating vacuum level from the designated pulsator 40. The pulsator 110 control device 112 includes a comparator for comparing the first signal to a stored reference signal representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for all milking system pulsators. The processor 110 control device 112 generates at least one control signal when the designated pulsator 40 pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range.

The control device 112 includes a control circuit which is responsive to at least one control signal for signaling that the designated pulsator 40 pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable to the milking system pulsators.

In Fig. 1, the control device 112 utilizes the control circuit to generate a signal by energizing a "red" illumination device to generate a visual signal that the pulsator has malfunctioned. The control device 112 then disables or shuts off the 25 volt direct current power to the solenoids 54 to deactivate and shut down the pulsator 40.

In an alternative embodiment, the control device 112 can energize a "green" illumination device to generate a visual signal that the pulsator is operating within pulsating vacuum levels programmed as acceptable for the milking system pulsators.

In still yet another alternative embodiment, the control device 112 can energize a "yellow" illumination device to generate a visual signal that the pulsator is operating within pulsating vacuum levels programmed as minimally acceptable for the milking system pulsators.

Fig. 2 is a pictorial representation of a milking apparatus comprising a milk claw 60 and four inflations 42 wherein each inflation has a teat cup having a shell and a teat cup liner provided in the shell to form a pulsation chamber between the teat cup liner and the shell. The milking system includes the

pulsator 40 for providing pulsation vacuum level pulses over line 50 to each inflation 42 and the pulsation vacuum level is applied as an input to the controller 104 for monitoring and controlling the pulsator 40.

Referring now to the chart illustrated in Fig. 3, the chart plots as curve 160 the milk flow rate as function of time during the above-described milking cycle of a cow using the data set forth in Table 1 above. Curve 160 shows that at the beginning of the milking cycle that maximum flow rate is reached with a minute or so. However, it takes about two minutes or so at end of the cycle to reduce to a zero flow rate. A typical milking cycle is about 6 minutes.

In the chart illustrated in Fig. 4, the chart plots as curve 162 vacuum level operation established by the vacuum source as a function of time during normal startup operation and shut-down of the vacuum system during a 6 minute milking cycle. As illustrated, by curve 162 in Fig. 4, when the vacuum is turned on, it immediately reaches a preset vacuum level of 12 inches Hg (12" Hg) which is the desired vacuum level and remains at that level until the end of the milking cycle.

In the pressure/time graph shown in Fig. 5, the continuous line 168 illustrates how the pulsating pressure in a pulsation chamber of a teat cup having a teat cup liner varies during a pulsation cycle. During an opening Phase A, depicted by 170 the pulsating pressure is decreased from about atmospheric pressure

to the milking vacuum or working vacuum as illustrated by 172. During the opening phase, the interior of the teat cup liner is open and milk can flow from the teat of a dairy animal.

During the open Phase A, the vacuum remains substantially at the working vacuum. The duration of the open Phase A is the time interval shown by 172 and 174. During the open phase, the interior of the teat cup liner is kept open.

A closing Phase C follows the open Phase B and the pulsating pressure increases from the milking vacuum or working vacuum level back to the atmospheric level and the time interval of the closing phase is shown by 174 and 176. The closing phase results in the interior of the teat cup liner closing. The closing Phase D, sometimes referred to as the resting phase, is essentially at atmospheric pressure and the time interval is shown by 176 and 178. During the close Phase D, the interior of the teat cup liner is kept closed.

A pulsation cycle comprising the Phases A through D usually last between about 0.7 seconds to about 1.5 seconds.

The "on" time for a pulsation cycle is the sum of the times of Phases A and B. The "off" for a pulsation cycle is the sum of the times of Phases C and D. The "on" time divided by the "off" time is the "on/off ratio. Typically this ratio is 60% on and 40% off. However, the ratio could be 50% on and 50% off or any other ratio determined by the operator, user or dairyperson.

A typical operating pulsator can be programmed to control the duration of each Phase that, in turn, establishes the on/off time ratio. In a computer controlled milking system, the pulsators are responsive to control signals that programmed the duration of each Phase and the on/off time ratio and the control signals can be used to adjust these and other operating parameters of the pulsator including disabling a malfunctioning pulsator, all under computer control.

As discussed herein below, the pulsator controller of the present invention provide a processor in the pulsator controller that is configured to be responsive to control signals to program in a designated pulsator the duration of each of Phases A, B. C and D and the on/off time ratio as well adjusting these and other operating parameters of the pulsator. The pulsator controller of the present invention include a processor that is responsive to the at least one control signal to at least one of; (a) signaling that a pulsator vacuum level is outside of the range of pulsating vacuum level programmed as acceptable for the milking system pulsator; (b) disabling the designated pulsator having a pulsator vacuum level that is outside of the range of pulsating vacuum level programmed as acceptable for the milking system pulsator; (c) signaling to a remote computer that the designated pulsator has a pulsator vacuum level that is outside of the range of pulsating vacuum level programmed as acceptable for the milking system pulsator; (d) responding to a

command signal from a remote computer that received a signal that the designated pulsator has a pulsator vacuum level that is outside of the range of pulsating vacuum level programmed as acceptable for the milking system pulsator.

In Fig. 6, the schematic representation of the controller 104 is illustrated as being operatively connected to a pulsator 40 of a milking apparatus. Since each milking apparatus has a pulsator, each pulsator will have a controller 104 operatively connected thereto to monitor and control operation of the pulsator 40 for the milk claw and inflations, as described above in connection with Fig. 1.

The controller 104 is operatively connected via a powered distribution device 184 to supply 24 volt direct current power over the common lead 186 and to power leads 188 and 190, respectively. In addition, the vacuum test lines 106 from the controller 104 are operatively connected to the pulsating lines 50. The pulsating vacuum level appearing on pulsating line 50 is carried by vacuum test lines 108 to the sensors 106. The controller 104 has a "red" illumination device 120 and a "green" illumination device 124 to visually indicate whether the pulsating vacuum level from a designated pulsator is operating outside of or within the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators, respectively, all under control of a control circuit of the monitoring device 144 of Fig. 1. A yellow illumination device

shown by dashed lines 122 may be used to signal that the pulsator vacuum level is at a minimum acceptable level for milking pulsator.

The controller is operatively connected to a source of 24 volts, direct current power, to a communication system to communicate with a remote computer, shown generally by arrow 372, and to receive a retract input signal from the pulsator represented by the 132.

Fig. 7 is a schematic diagram of the overall data processing system for controlling and monitoring all pulsators in a milking system. The data processing system includes a computer 220 which functions as a system processor. The term "computer" is intended to include all ancillary components such as, without limitation, network servers, storage devices including rotating disk memory storage systems, modems, communication lines, digital subscriber lines ("DSL"), keyboards and the like.

The computer system is operatively connected by a communication system, shown generally by arrow 222 to each of the pulsators in the milking system. In Fig. 7, milking system 1 is shown as having a pulsator "1", illustrated by 40, and a controller "1", illustrated by 104. The controller is operatively connected to a source of 24 volts direct current power 180 via power leads 186, 188 and 190. The controller "1" illustrated as 104 as operatively to the communication system 222 to facilitate transfer data between the computer 220 and the

controller "1" illustrated as 104. The controller "1" illustrated as 104 receives a signal indicating that the milking vacuum is on verifying that the milking apparatus has been attached to a dairy animal for milking and that a milking operation is to be performed.

Since a milking system has "N" milking apparatus, each of the milking apparatus has a controller, all of which are represented by controller "N" identified as 200 which are operatively connected to the communication system 222 via leads 226. Controller "N" identified as 200 likewise receives an input signal verifying that the milking vacuum for the milking system having the controller "N" illustrated by 200 is ready to commence a milking cycle.

The computer 220 via communication system 222 is operatively connected to an annunciator 232 which functions as a locked display and alarm device. The annunciator 230 can be actuated by the computer 220 showing the operating addition of all "N" pulsators in the milking system.

For example, if controller "1" illustrated by 104 generates at least one control signal when the designated pulsator "1" depicted by 40 is at a vacuum level outside of the predetermined vacuum range programmed as acceptable for the milking system pulsators, the controller "1" illustrated by 104 will de-energize the pulsator "1" thereby terminating operation of that milking apparatus and the "red" illumination device 120 will be

illuminated on the controller "1" illustrated by 104 and the same information would be visually provided at a selected remote location on the lock and display alarm 232.

The computer 220 contains in the computer memory the stored reference signal representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators. The computer can bifurcate, under program control, the stored reference signal into a first set of pulsating vacuum levels representing a range of pulsating vacuum levels programmed as highly acceptable for milking system pulsators and a second set of pulsating vacuum levels representing a range of pulsating vacuum levels programmed as minimally acceptable for milking system pulsators. In the controller, the processor would then generate a highly acceptable control signal when the designated pulsator pulsating vacuum level is at a vacuum level within the predetermined vacuum range for pulsating vacuum levels programmed as highly acceptable for milking system pulsators and a minimally acceptable control signal when the designated pulsator pulsating vacuum level is at a vacuum level within the predetermined vacuum range for pulsating vacuum levels programmed as minimally acceptable for milking system pulsators.

The control circuit of the pulsator controller would then be responsive to the highly acceptable control signal and the minimumally acceptable control signal for providing appropriate

signaling representing whether the designated pulsator pulsating vacuum level is at a vacuum level within or outside of the predetermined vacuum range for pulsating levels programmed as acceptable for the milking system pulsators.

The computer 220 can be operatively connected via lead 240 to the internet 250 via lead 248 or to a telephone line 246 via a lead 244 to transfer data signals between the computer and a remotely located device, such as a network server, either over the internet or telephone line.

Fig. 8 is a detailed block diagram of a controller 220 for practicing this invention. The controller 220 has a programmed microprocessor 260 which functions as a local processor in the controller 220. The microprocessor 260 receives a verification signal that the milking vacuum is on via lead 136. The microprocessor 262 communicates through a network controller 264 and lead 266 to a network computer 220 as illustrated in Fig. 7.

The microprocessor 260 receives a first signal representing a pulsating vacuum level for the front pair of inflations through a first input 302 and a pulsating vacuum level for the rear pair of inflation through a second input 304. The pulsating vacuum from the front and rear inflations are applied to inputs 302 and 304 via the vacuum test lines to the vacuum test ports as illustrated by lead 300. The first input 302 and a second input 304 have transducers or sensors which convert the pulsating

vacuum level to a electrical signal which are applied via leads 308 and 310, respectfully, to the programmed micro-processor.

Fig. 9 is a flow chart showing the steps of method of using the pulsator controller for monitoring and controlling a pulsator. In Fig. 9, a start signal represented by flow chart item 400 and represents that a milking cycle is to commence. The processor within the controller retrieves or reads the stored reference signals from the computer representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators. Absent a stop signal which would be generated by the stop signal represented by flow chart item 412, the milking cycle can commence and the controller has verified that a milking vacuum is present and that the milking apparatus is in fact attached to the dairy animal to be milked. The stop signal represented by flow chart item 412 has an input representing that a milking vacuum is present as represented by flow chart 412. The signal generated by the flow chart item 412 is applied as a yes to input 414 of the stop signal represented by flow chart item 412. The start signal of flow chart item 400 is applied as a yes input to the stop signal of flow chart item 472 as represented by lead 410.

When all the inputs to the stop signal represented by flow chart 412 are yes, then the output from the stop signal flow chart 412 is no as represented by lead 422. Since all the appropriate inputs to the stop signal of flow chart item 412 are

yes, no stop signal is required and for that reason a no appears on the lead 422.

The read pressure sensors and save data step as represented by flow chart item 424 is actuated sending an appropriate signal represented by lead 426 to the auto control mode represented by flow chart item 428. The auto control mode represented by flow chart item 428 can perform two functions based on whether or not an adjustment of timing of the pulsation cycle phases a through d is required. If an adjustment is required, then a yes signal is sent by auto control mode represented by flow chart item 428 via lead 430 to the step of adjust timing of phases a, b, c and d to read from memory as represented by flow chart item 436.

If the auto control mode represented by flow chart item 428 decides that no adjustment of timing is required, a no is communicated via lead 40 to bypass the adjust timing represented by flow chart item 436.

If an adjust timing is required as represented by flow chart item 436, the output is applied to the step of set front and rear output levels for the pulsators as represented by flow chart item 436. The step represented by flow chart item 436 will respond to either an adjust instruction from the adjust timing represented by flow chart item 436 or to a no represented by lead 440. If an adjustment is not necessary, the step of responding represented by flow chart item 436 will then respond to the no received from

the auto control mode of flow chart item 428 represented by lead 440.

The instruction performed by the flow chart item 436 is represented by lead 446 which is applied to the step of comparing to be performed by the processor as represented by flow chart item 448. The processor performs the step of comparing a first signal representing the pulsating vacuum level received from a designated pulsator to a stored reference signal, subject of flow chart item 402, representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators.

The instruction subject of flow chart item 448 is to set or enable a green, if present and available, a yellow or a red illumination device according to the pulsation state. In addition, instruction subject of flow chart item 448 would include disabling a designated pulsator which is determined by the controller. Also, in accordance with the instruction subject of flow chart item 448, a warning signal can be sent to a remote computer which monitors the entire milking system operation advising of the enabling of a yellow illumination device, if present, and warning of the enabling of a red illumination device which represents that the designated pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for all of the milking system pulsators.

In certain instances, the process may trigger a message sub-routine represented by: (i) flow chart item 406 which is responsive to a no instruction generated by the start signal of flow chart item 400 and (ii) message sub-routine 406' which is responsive to an instruction generated by the set in warning instructions generated by the flow chart item 448 which is applied via lead 450 to the message sub-routine represented by flow chart item 406', the output of which is applied back to the start signal instruction of flow chart 400, which output is represented by lead 456. The steps of the message sub-routine represented by flow chart items 406 and 406' are discussed below in reference to Fig. 10.

Fig. 10 is message sub-routine flow chart for flow chart item 406' of Fig. 9 showing the steps of method of using the pulsator controller for monitoring and controlling a pulsator. The message sub-routine flow chart of Fig. 10 also applies to the flow chart item 406 of Fig. 9.

In Fig. 10, the input to the message sub-routine 406 is represented by lead 450. The instructions is applied to a check data/instructions from computer represented by flow chart item 470. Upon completion of the instructions represented by flow chart item 470 the output is applied to a data/instructions step represented by flow chart item 474, the input to which is represented by lead 472. If the data/instructions represented by flow chart item 474 determines that no instructions are necessary

as represented by lead 490, the no instructions is applied to the output represented 482 from the message sub-routine 406'. If instructions are required, a yes instruction is generated as presented by lead 478 and the yes instruction is applied to a process data/instructions from computer as presented by flow chart item 480. The output from the processing step represented by flow chart item 480 is then applied to the output represented by lead 482.

Fig. 11 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing an alarm configuration display 500 for a designated controller. The alarm configuration display 500 discloses information relating to a designated pulsator which is one of a "N" number of pulsators in the milking system. The computer system can generate an alarm system display for every one of the "N" number of pulsators in the same format illustrated in Fig. 11.

In Fig. 11, the alarm configuration page 500 shows the setting rates and ratios, represented by 502, the setting system variables, represented by 504, the setting alarm parameters, represented by 508, if present, the minimum acceptable pulsating vacuum levels used for enabling a yellow illumination device is represented by 510 and the production of an unacceptable pulsating vacuum level signal which triggers the enabling of a red illumination device and the disabling of a pulsator is

represented by 512. In addition, the pulsating cycle times in milliseconds are represented by phase as shown by 514.

Fig. 12 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing on a display page 520 programmed stored reference signals to be applied to the processor from the computer system wherein the stored reference signal represents a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators. In Fig. 12, the alarm levels are set in milliseconds for phases a through d and a maximum and minimum vacuum in inches of Hg as shown by the data in box 528. Box 528 shows that the monitored values are averaged over three cycles. If a yellow illumination device is present in the monitoring system, the information contained in box 528 designates the minimum and maximum times to trigger or enable the yellow illumination device.

A red illumination device is present in the monitoring system for the reasons discussed above. The information contained in box 528 designates the minimum and maximum times to trigger or enable the red illumination device. Also, the information contained in box 528 for the triggering or enabling the red illumination device can concurrently be used by the controller to disable the designated pulsator when that designated pulsator pulsing vacuum level is at a vacuum level

outside of the predetermined vacuum range programmed as acceptable for the milking system pulsators.

Fig. 13 is a pictorial representation or monitor in a computer system used for monitoring the pulsators in a milking system showing on a display page 530 programmed phases of the pulsation cycle in milliseconds to be applied to all of the milking system pulsators. In addition, a continuous line representing the pulsating cycle is displayed as line 532 on the monitor. This cycle information is available for each one of the "N" pulsators in a control system.

In addition, the display page 530 includes a section showing additional information about the periods of each of the pulsation cycle Phases A, B, C and D as well as relevant information. The computer can display absolute data for the last cycle as represented by item 534 and can display the same information based on a three cycle average as represented by item 536.

Fig. 14 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system showing a display page 530' programmed phases of the pulsation cycle in percentage of a full pulsation cycle to be applied to all of the milking system pulsators. The information displayed on the display page of 530' of Fig. 14 is substantially identical to the display page 530 of Fig. 13 except that the last cycle data represented by 534' and a three cycle average data by 536' is shown in percentages of the pulsating cycle as opposed to

the data represented by 534 and 536 of Fig. 13, which data is displayed in milliseconds. The displayed information relating to cycle information shown by line 532' is identical to the information shown by line 532 in Fig. 13.

The following examples are provided:

Pulsation Cycle Examples

Example	Phase A	Phase B	Phase C	Phase D	Pulsator ON/OFF Ratio
A	10	50	20	20	60:40
B	10	55	20	15	65:35
C	10	40	20	30	50:50
D	18	44	15	23	62:38
E	12	48	12	28	60:40
F	10	60	15	15	70:30

The teachings of the present invention equally applied to a method and system for utilizing the controller for monitoring and controlling a pulsator as disclosed herein. As discussed herein below with reference to Figs, 15 through 18, the pulsator controller of the present invention can be used to both monitor and control the pulsation cycle.

The pulsator controller can be used in a method for monitoring and controlling an operating pulsator in a milking system. The method comprises the steps of: producing with a first sensor a first signal representing the pulsating vacuum level from a monitored operating pulsator; comparing with a processor the first signal representing a pulsating vacuum level from the monitored operating pulsator to a stored reference

signal representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators; and generating with a processor at least one control signal when the monitored operating pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range.

In addition, the method may further comprise the step of signaling with a control circuit responsive to the at least one control signal that the monitored operating pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

In addition, the method may further comprise including signaling with a first signaling device in responsive to the at least one control signal that a monitored operating pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

In addition, the method may further comprise the step of disabling with the control circuit in responsive to the at least one control signal the monitored operating pulsator having a pulsating vacuum level outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

Also, the pulsator controller can be used in a system for monitoring a milking system. The milking system has a plurality of milking apparatus each having inflations and wherein each of

the milking apparatus have a pulsator for controlling with pulsating vacuum the inflations when a milking apparatus is attached to a dairy animal and a milking vacuum is present in the milking apparatus. A source of milking vacuum is applied to each of the milking apparatus. A plurality of pulsator controllers is included in the milking system and one of each of the pulsators is designated for a designated one of the plurality of milking apparatus. Each of the pulsator controllers comprise a power input for receiving electrical power; a first input operatively connected to a pulsator to be monitored in a milking system for receiving from the monitored pulsator a pulsating vacuum; a first sensor operatively connected to the first input for producing a first signal representing the pulsating vacuum level in the monitored pulsator; a processor operatively connected to the power input for receiving electrical power and to the first sensor for receiving the first signal, the processor including a comparator for comparing the first signal to a stored reference signal applied to the processor from a computer wherein the stored reference signal represents a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators, the processor generating at least one control signal when the monitored pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range. A control circuit is responsive to the at least one control signal for at least one of signaling that the monitored pulsator

pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators and disabling operation of the monitored pulsator pulsating vacuum level which is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

The system may include the computer having the stored reference signals which represent the predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators is operatively connected to each of the plurality of pulsator controllers by a communication system.

In addition, the system may include the control circuit being responsive to the at least one control signal for signaling with a first signaling device that the monitored pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

In addition, the system may include the processor generating at least one of an acceptable control signal when a designed pulsator pulsating vacuum level is at a vacuum level within the predetermined vacuum range programmed as acceptable for the milking system pulsators and an unacceptable control signal when a designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range programmed as acceptable for the milking system pulsators.

In addition, the system may include the control circuit being responsive to the unacceptable control signal for signaling with a first signaling device that the monitored pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

In addition, the system may include the control circuit being responsive to the acceptable control signal for signaling with a second signaling device that the monitored pulsator pulsating vacuum level is within the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

In an overview, the computer controller monitoring and control is operable to control one component in a milking system. For example, if a pulsator controller signal to the computer that a yellow illumination device is activated or enabled, the computer can tract the pulsator and independently generate a warning signal in response to a programming monitoring criteria.

Also, a computer controlled monitoring and control system for a milking system is taught by the present invention. The computer controlled monitoring and control system for a milking system comprises a computer system including a memory configured for at least one of storing and retrieving stored data therefrom; a plurality of milking apparatus wherein each of the milking apparatus include inflations and a pulsator; a plurality of controllers for monitoring and controlling an operating pulsator

in a milking system wherein one controller is designated for one of the plurality of milking apparatus, each of the controller comprising a first sensor configured to be a operatively connected to a designated pulsator operating in a milking system for receiving a pulsating vacuum therefrom and for producing a first signal representing the pulsating vacuum level received from the designated pulsator; a processor operatively connected to the first sensor for receiving the first signal representing the pulsating vacuum level from the designated pulsator, the processor including a comparator for comparing the first signal to a stored reference signal representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators, the processor generating at least one control signal when the designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range; a control circuit responsive to the at least one control signal for signaling that the designated pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators; and a communication system operatively connected between the computer system, each of the controllers and other computer controlled milking system components, the communication system being configured to transfer control signals, data signals and instructions between the computer, each of the controllers and other computer controlled milking system components, the computer system having stored

therein reference data and instructions relating to operating parameters and conditions of each of the controllers and other computer controlled milking system components including wherein the processor in each controller uses the comparator for comparing the first signal to a stored reference signal applied to the processor from the computer system and wherein the stored reference signal represents a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators, the processor generating at least one control signal when the monitored pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range.

A method for using pulsator controllers in a computer controlled system for a milking system is also taught by the present invention.

The method for using a computer controlled monitoring and control system for a milking system comprising (i) at least one of storing and retrieving stored data from a computer system memory; (ii) providing a plurality of milking apparatus wherein each of the milking apparatus include inflations and a pulsator; (iii) providing a plurality of controllers for monitoring and controlling an operating pulsator in a milking system wherein one controller is designated for one of the plurality of milking apparatus, each of the controller comprises a first sensor configured to be a operatively connected to a designated pulsator operating in a milking system for receiving a pulsating vacuum

therefrom and for producing a first signal representing the pulsating vacuum level received from the designated pulsator; a processor operatively connected to the first sensor for receiving the first signal representing the pulsating vacuum level from the designated pulsator, the processor including a comparator for comparing the first signal to a stored reference signal representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators, the processor generating at least one control signal when the designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range; a control circuit responsive to the at least one control signal for signaling that the designated pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators; (iv) operatively connecting a communication system between the computer system, each of the controllers and other computer controlled milking system components wherein the communication system is configured to transfer control signals, data signals and instructions between the computer, each of the controllers and other computer controlled milking system components and the computer system has stored therein reference data and instructions relating to operating parameters and conditions of each of the controllers and other computer controlled milking system components including wherein the processor in each controller uses the comparator for

comparing the first signal to a stored reference signal applied to the processor from the computer system and wherein the stored reference signal represents a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators; and (v) generating with the processor at least one control signal when the monitored pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range.

Pulsator Controller for Monitoring, Controlling and Adjusting the Operating Characteristics of a Pulsator

Figure 9 shows by element 436 that the pulsator controller flowchart representing, the pulsator controller software, can enable the pulsator controller 100 to adjust the operating characteristics of the pulsator, namely adjust timing of phases a, b, c and d to read from memory. Memory can be either the processor memory within the pulsator controller 100 or the memory of the computer 220.

Fig. 15 is a modification of the detailed block diagram of a controller of Fig. 8 and includes elements to enable the pulsator controller to utilize the processor for generating an information signal representing a pulsator malfunction using a look up table as a reference table, a visual display to display in writing the pulsator malfunction and an output for applying operating control signals to a pulsator to adjust the operating

parameters of the designated pulsator controlled by the pulsator controller.

In Fig. 15, the processor 260 has a memory 400 for storing pulsator malfunction criteria as a reference table. The memory 400 may also be used for storing reference signals representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators. In addition, the memory 400 could be used for storing command signals generated by a remote computer for response to the remote computer receiving a signal from the processor within the pulsator controller that the designated pulsator has a pulsator vacuum level that is outside of the range of the pulsating vacuum levels programmed as acceptable for the milking system pulsator. The command signal can perform a number of functions such as, for example, applying a operating control signal to the designated pulsator to adjust the duration time of a Phase, to control or adjust the on/off time ratio and to disable or disconnect the designated pulsator.

The information and data contained in the look up table is utilized by the processor for matching data from a control signal generated by a sensor monitoring vacuum level in a pulsator to data in the look up table to find a match so that the processor can generate an information signal to identify the pulsator malfunction. The format of the look table, the alarms involved and pulsator malfunction or problem diagnosed is as follows:

Alarm No.	Description	Limited violated
1	No phase detected	
2	PPM or Rate On out of range	Rate On and PPM variation %
3	Phase B vacuum to high	Phase B Vacuum range
4	Phase B vacuum too low	Phase B Vacuum range
5	Phase D vacuum to high	Phase D maximum vacuum
6	Phase A too short	Minimum Phase A
7	Phase B too short	Minimum Phase B
8	Phase C to short	Minimum Phase C
9	Phase D too short	Minimum Phase D

Alarms involved	Problem diagnosed
1 (and any other)	"Hose disconnected or no vacuum present or bad coil in pulsator"
4 (and any other)	"Vacuum too low, check air leaks"
3 (but not 1 or 4)	"Vacuum too high, check vacuum regulator"
6 or 8 (and nothing else)	"Cow stepping on hose, or hose clogged"
2 or 7 or 9 (and nothing else)	"Pulsator dirty, pulsator sticking or fresh air restriction"

In addition, Fig. 15 includes an output represented by lead 402 which is responsive to the processor for adjusting pulsator operating parameters in response to an operating control signal generated by the processor 260 and applied by output 402 to the designated pulsator. In addition, Fig. 15 also includes an annunciator or video monitor display 408 which is used by the pulsator monitor to display a written message showing the pulsator malfunction generated by the processor 260 in response to a match in the reference table stored in memory 400.

In Fig. 16, the pictorial representation of a monitor in a computer system for monitoring the pulsators in a milking system showing programmed Phases of the pulsation cycle in milliseconds as applied to all of the milking system pulsators is shown.

In Fig. 16, there are two wave forms shown by elements 410 and 412 which represent the vacuum pulse level from a designated pulsator from a front control valve and a rear control valve,

respectively. The wave form shown in the monitor and the vacuum level readings shown for both the front and rear control valves shows the duration times for Phases A, B, C and D as well as the "on" time which is the sum of the times of Phase A plus Phase B and the "off" time which is the sum of Phases C plus D. In addition, the maximum vacuum level is shown to be 12.6 inches of Hg and the minimum vacuum level is shown to be 0.0 inches of Hg. The pulse per minute is 60 which indicates that there are 60 cycles comprising Phases A, B, C and D every minute of operation of the designated pulsator. The display illustrated in Fig. 16 discloses that none of the designated pulsators are malfunctioning.

Fig. 17 is a pictorial representation of monitor in a computer system used for monitoring the pulsators in a milking system for programming into the system tolerance levels and other information to be used by the computer system for generating an alarm in a response to signals received from the pulsator. The pictorial representation of the monitor in Fig. 17 includes a display wherein the operator, user or dairy person could program the computer system or the processor in a processor controller to monitor the pulsator, to control the pulsator and to generate an information signal in the form of an alarm when the program tolerance levels are exceeded by the measured and monitored pulsator vacuum level. In Fig. 17, the monitor display shows under the portion of the display labeled "Alarm Limits" the

programmed limits for: (a) cycles to average for reading; (b) programmed alarm levels for: (i) percentage tolerance variation of programmed vacuum pulse levels to trigger alarm; (ii) Phase D maximum vacuum; (iii) Phase B maximum and minimum vacuum level and (iv) minimum phases timed durations for Phases A, B, C and D. Also, the monitor display shows that the pulses per minute is programmed at 60 pulses per minutes and that the "on" time is programmed at 60 percent and the "off" time is programmed at 40 percent.

If the rate "on" time and the PPM varies more than 2 percent a control signal would be generated by the processor and an information signal would be generated indicating that the tolerance of 2 percent was exceeded.

The processor operates in a similar manner if the Phase D maximum vacuum exceeds 0.10 inches of Hg; if the Phase B vacuum range exceeds an upper limit of 12.76 of Hg or a lower limit of 12.26 inches of mercury; if Phase A timed duration is less than 55 msec; if Phase B timed duration is less than 400 msec; if Phase C is less than 60 msec and if Phase D is less than 100 msec.

The flow chart of Fig. 18 shows pictorially the order in which the programmed alarmed levels are monitored by the processor in the pulsator monitor using the memory of processor 260 or by the processor communicating with a remote computer including the memory thereof to respond to the control signals to

generate an information signal designating a pulsator malfunction.

In Fig. 18, alarm 1 designated as 420 is generated if a hose is disconnected, or if no vacuum is present or if a bad coil is present in the pulsator. Alarm 4 designated by element 424 is generated if a vacuum is too low or if an air leak exist. Alarm 3 designed by element 428 is generated if a vacuum is too high which may occur if the vacuum regulator is not working properly.

Alarm 6 or alarm 8 designated by element 430 is generated if a cow steps on a hose or a line having a vacuum is occluded or clogged.

Alarm 2, 7 or 9 designated by element 432 is generated if the designated pulsator is dirty, or if the pulsator is sticking or if a fresh air restriction appears to be present.

In the preferred embodiment, the pulsator controller, as used in a milking system, comprises a first sensor that is configured to be a operatively connected to a designated pulsator operating in a milking system for receiving a pulsating vacuum therefrom and for producing a first signal representing the pulsating vacuum level received from the designated pulsator. A processor has a memory for storing pulsator malfunction criteria as a reference table and stored reference signals representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators. The processor is operatively connected to the first sensor for receiving the first

signal representing the pulsating vacuum level from the designated pulsator. The processor includes a comparator for comparing the first signal to the stored reference and generates at least one control signal when the designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range. In addition, the processor generates at least one information signal from the pulsator malfunction criteria reference table identifying the pulsator malfunction represented by the at least one control signal. A control circuit is responsive to the at least one control signal for signaling that the designated pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators.

As discussed above, the reference table for storing the pulsator malfunction criteria includes a look-up table comprising a listing of pulsator malfunctions classified by data contained in a control signal enabling the processor to match a control signal having control signal data to the pulsator malfunction criteria in the reference table and when the control signal data and particular pulsator malfunction criteria classified by data contained in a control signal. The processor generates an information signal identifying the matched pulsator malfunction criteria for the designated pulsator. The control circuit is responsive to the information signal for generating a visual display representing the matched pulsator malfunction criteria

for the designated pulsator. The visual display may be a display light, a written message on an annunciator, a written message on a video monitor or other appropriate signaling device as is known to those skilled in the art.

The processor in pulsator controller may be operatively connected to a remote computer having a memory for storing pulsator malfunction criteria as a reference table and the at least one information signal is generated by the processor from the pulsator malfunction criteria reference table in the remote computer for identifying the pulsator malfunction represented by the at least one control signal.

The pulsator controller processor may include in the software or program a programmable tolerance range for at least one of: (a) cycles of pulses to be averaged for monitoring, percentage variance in the range of pulsating vacuum level programmed as acceptable for the milking system pulsators, (b) maximum Phase D vacuum pressure level, (c) Phase D range of acceptable vacuum levels; and (d) minimum time duration for a selected Phase.

The processor pulsator malfunction criteria stored in the reference table may include at least one of: (a) at least one of a low vacuum; (b) high vacuum; (c) defective coil in pulsator, (d) pulsator component malfunction. E.g. pulsator coil is dirty or coil is sticking, and (d) vacuum line occlusion. e.g., cow has stepped on hose having a vacuum.

The pulsator controller processor may be operatively connected to a remote computer having a programmable pulsator operating characteristics control which a operator, user or dairyperson would use to set desired operating characteristics for one or more designated pulsates in the milking system. In such a configuration, the pulsator controller further includes an output operatively connected to the designated pulsator for receiving from the processor operating control signals for programming the operating characteristics of the designated pulsator. The output is responsive to the processor for applying to the designated pulsator operating control signals for the designated pulsator received from said remote computer as programmed by the pulsator operating characteristics control.

The pulsator controller can control the operating phases designated as Phases A, B, C and D and the processor can control the ratio of on time to off time wherein the on time is the sum of the operating times of Phase A and Phase D the off time is the sum of the operating times of Phase B and Phase C. In addition, The pulsator controller can adjusting the duration of each of the operating times of Phases A, B, C and D.

The pulsator controller monitors, controls and adjusting the operating parameters of a pulsator having an electrically controlled valve to alternatively apply atmospheric pressure and a pulsating vacuum to a milking machine. The pulsator controller includes a first sensor configured to be a operatively connected

to a designated pulsator operating in a milking system for receiving a pulsating vacuum therefrom and for producing a first signal representing the pulsating vacuum level received from the designated pulsator. A processor has a memory for storing pulsator malfunction criteria as a reference table and stored reference signals representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators. The processor is operatively connected to the first sensor for receiving the first signal representing the pulsating vacuum level from the designated pulsator. The processor includes a comparator for comparing the first signal to the stored reference and the processor generates at least one control signal when the designed pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range; and at least one information signal from the pulsator malfunction criteria reference table identifying the pulsator malfunction represented by the at least one control signal. A control circuit is responsive to the at least one control signal for signaling that the designated pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators and an operating control signal from the processor is applied to a designated pulsator to adjust the operating parameters thereof in response to said operating control signal.

A method for monitoring an operating pulsator in a milking system is taught herein. The method comprises the steps of: producing with a first sensor a first signal representing the pulsating vacuum level from a monitored operating pulsator; comparing with a processor said first signal representing a pulsating vacuum level from the monitored operating pulsator to a stored reference signal representing a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators; and generating with a processor at least one control signal when the monitored operating pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range and at least one information signal generated by the processor from a pulsator malfunction criteria reference table identifying the pulsator malfunction represented by the at least one control signal.

The method may include the processor being operatively connected to a remote computer having a programmable pulsator operating characteristics control and further comprising the step of receiving from the processor operatively connected to the designated pulsator operating control signals for programming the operating characteristics of the designated pulsator; and applying through an output to said designated pulsator programmed pulsator operating control signal for the designated pulsator received from said remote computer as programmed by the pulsator operating characteristics control.

The method may further comprising the step of signaling with a control circuit responsive to said at least one control signal that the monitored operating pulsator pulsating vacuum level is outside of the range of pulsating vacuum levels programmed as acceptable for the milking system pulsators..

This invention discloses and teaches a system wherein the system includes a milking system having a plurality of milking apparatus each having inflations and wherein each of the milking apparatus have a pulsator for controlling with pulsating vacuum the inflations when a milking apparatus is attached to a dairy animal and a milking vacuum is present in the milking apparatus. The system includes a source of milking vacuum applied to each of the milking apparatus and a plurality of pulsator controllers one of each being designated for a designated one of the plurality of milking apparatus. Each of the pulsator controllers may comprise the elements as disclosed hereinbefore.

A computer controlled monitoring and control system for a milking system is also disclosed and taught herein. The system comprises a computer system including a memory configured for at least one of storing and retrieving stored data therefrom, a plurality of milking apparatus wherein each of said milking apparatus include inflations and a pulsator and a plurality of pulsator controllers for monitoring an operating pulsator in a milking system wherein one controller is designated for one of the plurality of milking

apparatus. Each of the pulsator controllers may comprise the elements as disclosed hereinbefore.

The system includes a communication system operatively connected between the computer system, each of the pulsator controllers and other computer controlled milking system components. The communication system is configured to transfer control signals, data signals and instructions between the computer, each of the pulsator controllers and other computer controlled milking system components. The computer system has stored therein reference data and instructions relating to operating parameters and conditions of each of the pulsators and other computer controlled milking system components including wherein the processor in each pulsator controller uses the comparator for comparing the first signal to a stored reference signal applied to the processor from the computer system and wherein the stored reference signal represents a predetermined vacuum range of pulsating vacuum levels programmed as acceptable for milking system pulsators. The processor generates at least one control signal when the monitored pulsator pulsating vacuum level is at a vacuum level outside of the predetermined vacuum range. The processor in the pulsator controller may generate at least one information signal generated by the processor from the pulsator malfunction criteria reference table identifying the pulsator malfunction represented by the at least one control signal.

It is envisioned that the pulsator controller in substantially the preferred embodiment or a variation thereof may have utility for other dairy animals, such as goats. It will be appreciated that various alterations and modifications may be made to the pulsator controller to enhance the functional characteristics thereof. All such variations and modifications should be considered to fall within the scope of the invention as broadly hereinbefore described and as claimed hereafter.

All such uses, variations, modifications and the like are anticipated to be within the scope of this invention.

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